NiteOwl

Part Two

1. NiteOwl and the Small Payloads Program Objectives

The NiteOwl project should be considered in a broad perspective. The parachute-borne spectrographic images of ozone absorption taken while descending through the lower stratosphere and upper troposphere simulate the observations that could be acquired from a satellite in low Earth orbit (LEO). While a rocket borne experiment cannot provide global coverage, it is an important validation step toward a future micro-satellite experiment. These innovative and cost-effective measurements will provide specific data regarding ozone in the upper troposphere and lower stratosphere (UTLS) during the Arctic winter, with the spatial resolution required by current predictive ozone models

The NiteOwl project will provide ample opportunities for graduate students and, in some instances, undergraduate students to be involved in all stages of the project due to the type and scope of the instrument involved. The participation of eight graduate students in preparing the NiteOwl proposal is a clear indication that this work can be done, and done well, with young researchers. Graduate student participation will continue during the hardware specification, design and integration phases of the project. Subsequent data analysis and calculation of the ozone vertical and horizontal distributions require expertise from researchers in various disciplines such as software engineering, computer tomography, theory of inverse problems, atmospheric chemistry, geophysics of the upper and lower atmosphere, and image analysis. The project will demonstrate the synergy of a multidisciplinary team of university scientists working closely with an industrial partner.

The NiteOwl project is very important for the industrial partner, SCI-TEC Instruments Inc.. Currently, SCI-TEC manufactures world class optical instruments for ground-based monitoring of the ozone layer. SCI-TEC's participation will give the company an opportunity to extend their product line to include optical instrumentation for micro-satellite/satellite measurements of ozone concentration. More importantly, data obtained from orbit by the stellar occultation technique can be used to generate near-real-time ozone maps with regional, national, or global coverage. This is a first step for SCI-TEC toward the development of a high value-added data product and will strengthen their ability to compete internationally. Rocket experiments are also important for Bristol Aerospace Ltd. (BAL) and Akjuit Aerospace Inc. (AAI). Their participation in this project allows them to enhance their industrial capabilities in the manufacture and launch of rocket payloads.

The NiteOwl project will address key scientific requirements for an improved understanding of ozone trends and will also take a key step toward meeting future information needs of Canadians. All participants in the project recognize that improved ozone measurements are timely, and are an appropriate response to increasing public concern over ozone depletion. This phenomenon is of vital

draft

importance to Canada because of its vast Arctic and sub-Arctic regions. Global ozone monitoring by stellar occultation will make an important contribution to international efforts to understand the nature of ozone variations in the upper troposphere and lower stratosphere.

2. Top-level Science Requirements

The NiteOwl project will use starlight to obtain images from which column ozone densities between the imaging spectrophotometer and the stars observed can be determined to within 5%. The ozone distribution within a radius of 600 km will then be determined with 12% RMS uncertainty, with a vertical resolution of 3 km, a radial resolution of 200 km, and an azimuthal resolution of 10°, over a 45° azimuth sector.

3. Instrument

3.1 Imaging Spectrograph

The imaging spectrograph (ISG), illustrated schematically in Figure 2-1, consists of two main optical elements: a transmission diffraction grating (§3.1.2) and an objective lens (§3.1.3). The collimated light from each star in the instrument field of view is dispersed by the diffraction grating into a spectrum, which is focussed onto a CCD detector by the objective lens. The objective lens defines the entrance pupil and hence the light grasp of the ISG, and is thus the element on which the requirement for 100:1 SNR (Part I, §2.3) places the most stringent demands (cf. §3.1.3). The other components of the ISG are the entrance window, baffles, and optical filters preceding the diffraction grating which, respectively, define the instrument field of view, minimize stray light incident on the grating, and define the wavelength passband, and the CCD detector which records the irradiance produced by each star. These two sections of the instrument are described in §3.1.1 and §3.1.4.

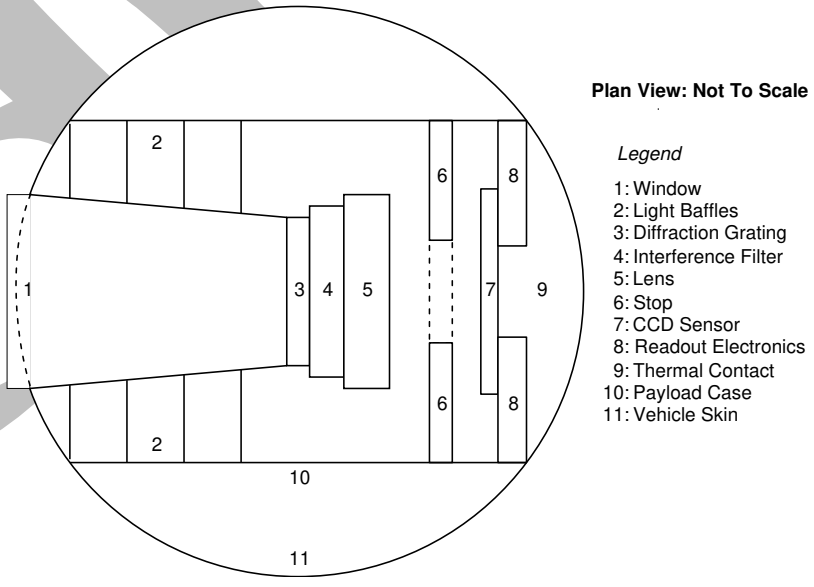

Fig. 2-1. Schematic diagram of imaging spectrograph.

3.1.1 Window, Entrance Baffles, and Optical Filter(s)

The entrance window of the ISG will be a simple opening in the payload skin that will be covered during launch. The window cover will be ejected just after the payload reaches apogee. The size of the opening will be determined by a tradeoff between minimizing the window area (to simplify the engineering of the window cover) and minimizing the solid angle subtended by the window at the center of the transmission grating (to reduce the vignetted portion of the sky from which stellar energy reaches the grating). Between the window and the diffraction grating a series of knife edge baffles will reject light from outside the field of view and minimize the amount of light reflected onto the grating from within the instrument. Finally, a stop between the objective lens and the CCD detector will eliminate internal reflection and scattering that would otherwise contaminate the image at the CCD.

Blocking filters will be used to define the limits of the wavelength passband of the NiteOwl ISG. These will reject wavelengths shorter than 400 nm and longer than 780 nm, in order to avoid spectral overlap on the CCD between adjacent orders of diffraction.

Because the launch site at SpacePort Canada (Churchill, MB) lies at the center of the statistical auroral zone, the ISG may view auroral emissions at times during the mission, even when viewing the prime target stars to the south. Certain airglow emissions from the upper atmosphere will also be seen. The emission wavelengths of primary concern are the [OI] emissions at 557.7 nm and 630.0 nm, as these lie near the center of the ozone Chappuis absorption and are prominent in the spectra of both the nightglow and the aurora. We have considered the wavelength passband options described in Table 2-1. Option 1 is favoured but a final decision will be taken on the base of detailed instrument modelling to be carried out in Phase A.

Table 2-1. Wavelength Passband Options for Imaging Spectrograph

Option	**1**	**2**	**3**
Filter Type	Bandpass: 400 - 780 nm	Notch: reject 557.7 nm and 630.0 nm	Bandpass: 560 - 620 nm
Number of Components	One bandpass or (one highpass + one lowpass)	Same as Case 1, with two notch filters	Same as Case 1
Advantages	Measure whole visible spectrum, no data lost	Reject only airglow and auroral spectrum; rejection bands mark wavelengths	Minimal background auroral contribution - “dark sky”
Disadvantages	Strong aurora may compromise data	Wide rejection bands and out-of-band “ripple”	Limited wavelength band (60 nm)

3.1.2 Transmission Grating

A transmission grating with a ruled area of 100 × 100 mm and a ruling frequency of 75 lines/mm will be used to disperse the incident starlight. This results in a spectral resolution of 3.4 nm/pixel in first order, and spectral features wider than 8 nm will be resolved over the entire